PRF03 September 02 Friday
Mission Report
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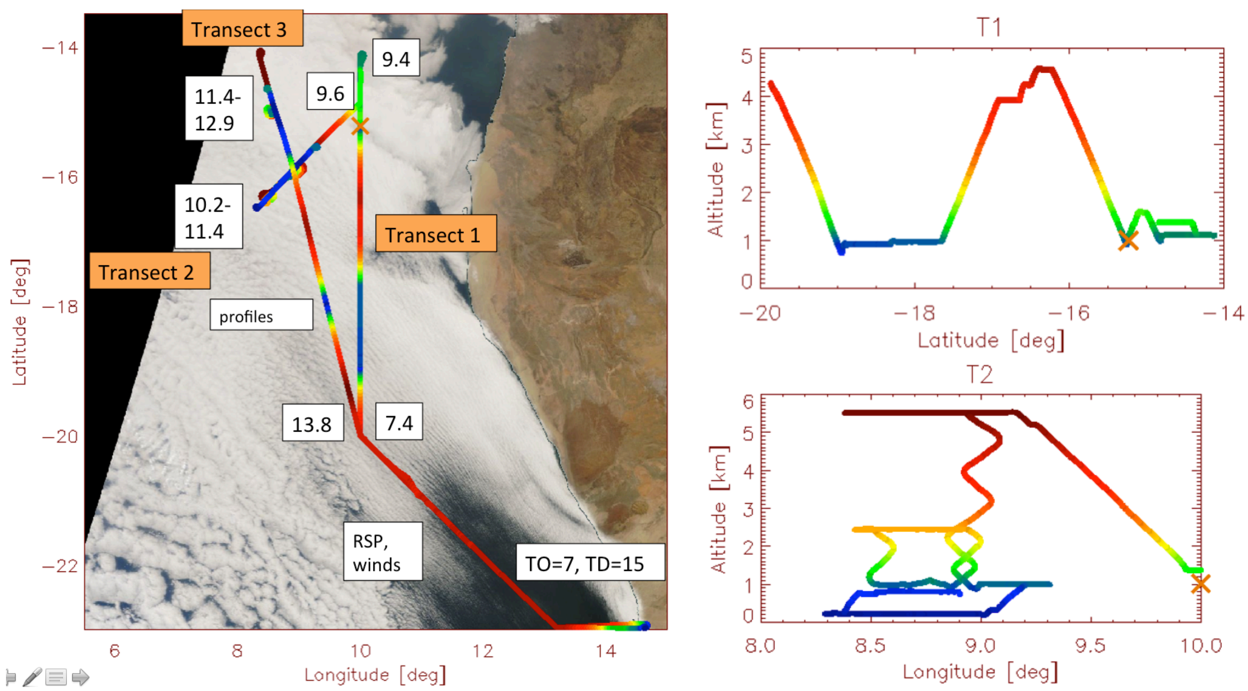
mission scientist: Jens Redemann

Primary flight objective:

First flight to sample aerosol radiative effects above clouds to 20S, 10E where the aerosol plume and low-cloud deck are increasing towards the north. As first step, capture CF=100% case. Significant in-situ aerosol and cloud sampling, connection to remote sensing through Terra overpass. Requirements for the flight: no Cirrus or mid-level clouds; high AOD; solid low-level cloud deck (all met).



Flight pattern with Terra (09:10) RGB context. Color-coded by altitude and labeled with UTC times. Three transects of the area: T1: S→N, T2: principal plane wall 1, T3: principal plane wall 2; Location of P-3 at Terra overpass marked x

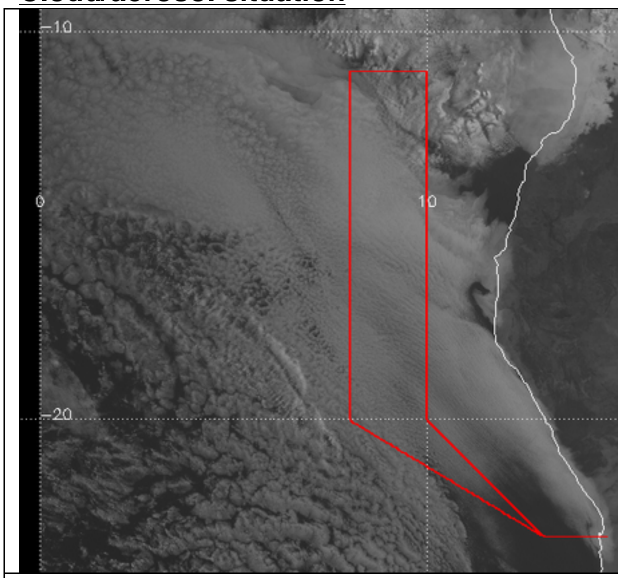
Flight Summary:

- The original plan was to map the aerosol layer properties while transiting to focus area between 20S-11S and 10E-8E, and then set up one radiation/microphysics wall. Instead, we did two radiation walls near 16S because the conditions were optimal in terms of clouds (avoided mid- or high-level clouds further north; that gave us more time to work in the south)
- Flight consisted of three transects through the area: T1 (South-North) from UTC~7.4…9.6 with two full in-situ profiles and a Terra overpass, T2 (NE-SW) from UTC~9.6…11.4 with one full radiation wall (wall #1) including square spirals, T3 (NW-SE) from UTC~11.4…13.8 with an almost complete radiation wall (wall #2) at northernmost point (UTC~11.4…12.9), as well as two full in-situ profiles at similar latitude as on T1 on outbound flight

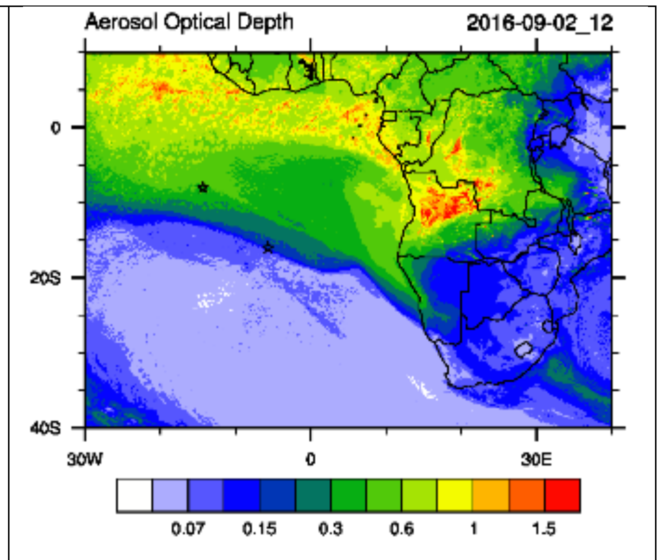
- Used transit to T1 to optimize in-situ instrumentation, and transit after T3 for RSP legs and wind maneuvers
- Near Terra overpass, crossed boundary between two air masses (difference caused mainly by warmer SSTs in the North); the resulting differences in clouds are *not* caused by differences in aerosols.
- The two radiation walls differ slightly in terms of aerosol and cloud properties; the initial motivation for setting up the second radiation wall was to either find larger AODs in the North, and/or to find clouds with different properties (e.g., in terms of the albedo)

<u>Manifest</u> Michael Singer, Mark Russell, Brian Yates, Todd Brophy, Mike Terrell (crew), Sebastian Schmidt, Steve Durden/Greg Sadowy (APR), Kenneth Sinclair (RSP), Stefan Freitag (HIGEAR-1), Nikolai Smirnow (HIGEAR-2), Amie Dobracki (AMS), Mary Kacarab (CCN), David Noone (WISPER), Jim Podolske (COMA), Siddhant Gupta (cloud probes/PDI), Scott Kittelman/Sabrina Cochrane (SSFR), Mike Delaney (data), Patrick Hambloch (AMPR), Samuel LeBlanc (4STAR), Jane Peterson (public outreach)

<u>Cloud/aerosol situation</u>



RGB@7:15, guiding the in-flight decisions

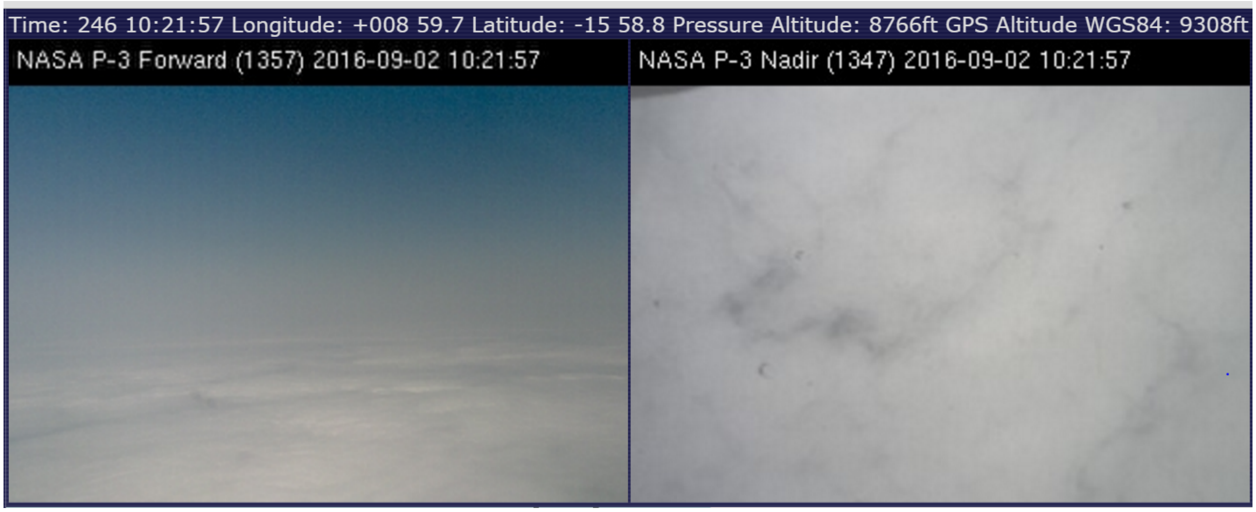


Forecast of AOD

<u>Clouds</u>: Based on the RGB imagery early on in the flight, we expect mid-level clouds north of 14S and a solid low-level cloud deck elsewhere. Later, the ground confirms that we should stay south of 14S because of the mid-level clouds. Since we lose connection on the northbound leg, we decide to strictly stay south of 14S. After catching the Terra overpass on the northern end of T1, we set up T2 south of that, on a NE/SW orientation (to optimize principle plane conditions at the same time). The cloud morphology changed somewhat on T2; in some areas it looked completely homogeneous, in others the camera and SSFR picked up slight variations of the cloud field albedo.

<u>Aerosols</u>: 4STAR confirmed the location of the gradient, but the optical thickness was slightly lower than forecast.

The aerosol/cloud situation on T3 (wall #2) was not significantly different from the situation on T2 (wall #1). The biggest difference was that the clouds in wall #1 were drizzling in some areas, whereas the ones in wall #2 were not. Mixing of the aerosol and cloud layer may have been different in the two locations, to be determined from the in-situ profiles.

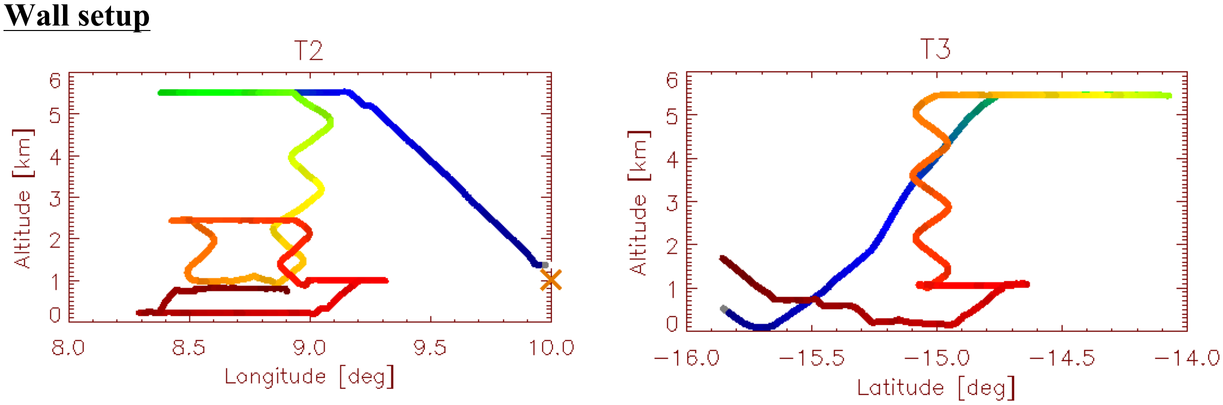


This picture shows the cloud/aerosol situation for the first wall – not very different visually from the second one. The optical thickness, however, was not as homogeneous as the image suggests – suggested by SSFR albedo variability.

Satellite overpasses

- Terra 9:10 (above clouds, below aerosol layer at this point) – this should be a good case for above-cloud aerosol retrieval validation
- Suomi NPP 13:30; A-Train 13:40 (well above clouds) – this could be a case for liquid water path validation, perhaps also CloudSat/APR comparisons, although no direct underflight

Wall setup



Wall #1 (on transect 2) and wall #2 (on transect 3, northern part), both color-coded by time (blue to brown). *Both walls were set up in principle plane to optimize RSP remote sensing.*

Description:

#1 (T2) UTC=[9.6,11.6] (varying cloud structure, but always overcast; drizzle)

- profile up, and survey area at high altitude; reverse to spiral location
- downward square spiral (zero-roll 30 sec segments every 180 deg in heading)
- above-cloud leg #1 (5 min)
- profile to center of aerosol layer (as determined on the previous profile)
- in-situ sampling (5 min)
- profile down at earlier spiral location; dip into clouds
- above-cloud leg #2 (5 min)

- profile through clouds, and sample below clouds (>10 min)
- in-cloud leg (>5 min)

#2 (T3) UTC=[11.6,12.9] (more homogeneous than #1; no drizzle; higher WP)

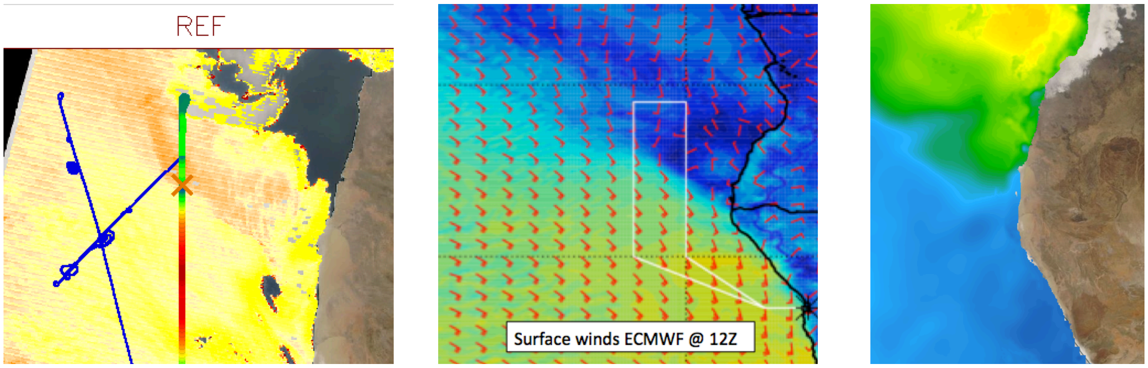
- descent to minimum altitude below clouds
- full profile up
- high-altitude survey/remote sensing leg
- square spiral down
- above-cloud leg
- profile through clouds, followed by below-cloud leg
- in the interest of time, the in-cloud leg was conducted en route heading home
- full profile up
- The timing does allow another set of profiles after completion of the second wall, as well as wind maneuvers on the transit back.

<u>Individual instrument/science reports</u>

- APR/AMPR: both good data, especially during one leg (precipitation, wall #1, transect 2). Also, near coordination with CloudSat (where on level leg during the overpass). APR had a computer failure towards the end, but got it back up again. In general, AMPR would like to see longer legs (only had one)
- RSP: multiple principle plane runs (3); much more cloud observation time than expected. However, there were problems with the scanner. In retrospect, we know that only segments with 200 knts worked for retrievals (data in the “square spirals” were good).
- HIGEAR/AMS: good flight, used first part of it to optimize instruments; sampled all pollution layers; data set seemed to be consistent with observations by CCN and COMA
- CCN: worked well, tried different sampling modes during last 15 minutes of the flight
- PTI: not on
- COMA: worked well, but ozone measurements affected negatively after ingesting water during cloud penetration; interesting vertical structure in CO and CO_2
- Cloud Probes/PDI: Saw drizzle on one of the legs (consistent with APR observations); CAPS not working, but other data are good; PCASP shows synergy with probes behind inlet; PDI initially not working (problem with buffer) but data should be fine
- 4STAR: worked well, several sky scans, mid-VIS AOD peaked around 0.4…0.5
- SSFR: worked well, two walls and several spirals; should see contrast in terms of aerosol and cloud properties between two cloud walls; problem with aircraft reflections
- WISPER: good data, especially above vs. below-cloud runs
- Data system: Normal aircraft data worked fine, but Inmarsat had problems, Iridium backup but had several dropouts
- Winds: Executed maneuvers (speeds, tail wags, etc.). Did not get to reverse headings though.

<u>Cautionary note regarding indirect effect</u>

We happened to intercept two different air masses on our first transect, and we fortuitously flew just above clouds (with a few dips into the clouds for microphysics validation of MODIS). The Terra retrievals show a different effective radius for constant liquid water path. But this contrast was not related to a change in aerosols; rather, it seems to be caused by the meteorological conditions (the surface winds are shown in the figure below, with a sharp gradient and an eddy close to the transition in the effective radius). However, the change in effective radius to the west of the first wall (also shown in the satellite retrievals) *could* be related to aerosol mixing.



Effective radius retrievals from Terra, surface wind field, and sea surface temperature. North and south of the Terra overpass location (x), the effective radius is significantly different (with similar liquid water path) because the boundary of a different air was located there (as indicated by the surface winds on the right). This may in turn be related to a large contrast in SST.

<u>Metrics for achieved science objectives</u> [green for full, red for partial]

Direct Forcing

SO1-1 evolution of BBA properties with transport:

Full profiles at 7 different locations *across* the plume (but not along)

[The metric here could be age of plume and/or distance from shore. Distinguish partial characterization (routine flight profiles with mainly in-situ measurements) vs. full radiation/in-situ characterization, which allow in-situ + radiation/remote sensing together]

SO1-2 aerosol radiative effect as function of cloud/aerosol properties:

2 cases. AOD~0.5. CF~100, but different COD on two walls

[The metric here could be (1) aerosol properties, (2) cloud properties, e.g., (1a) AOD500, (1b) SSA500, (1c) AAE, (1d) hygroscopicity, (2a) cloud fraction, (2b) COD, (2c) Reff; other cloud parameters such as Nd, precip are important for other objectives.]

SO1-3 factors that control seasonal variation of aerosol

n/a

Semi-Direct Effect

SO2-1 relative aerosol-cloud vertical distribution:

3 transects with full or partial profiles (total of 6.8 hours)

SO2-2 constrain aerosol heating rates:

2 full heating rate profiles (1.0 hours each)

[The metric here could be # of cases of full walls.]

SO2-3 cloud micro/macrophysics:

n/a

Indirect Effects

SO3-1 aerosol-BL mixing:

2 cases with beginning aerosol-BL mixing for young, stratified plume

SO3-2 cloud changes as function of mixing

2 cases in terms of mixing and cloud microphysics

SO3-3 precipitation susceptibility

2 contrasting cases (1 drizzling vs. 1 non-drizzling cloud), but the difference is not necessarily due to differences in aerosol mixing; TBD